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Sir:

Transmitted herewith for filing is the patent application of:

Inventors: Robert Bedichek, Linus Torvalds, and David Keppel,

Entitled: METHOD FOR INTEGRATION OF INTERPRETATION AND TRANSLATION
IN A MICROPROCESSOR

Enclosed are:

- XXX Three (3) sheet(s) of Formal Drawing(s) including four (4) figures.
XXX An Assignment of the invention to Transmeta Corporation on Sept.28, 1999.
XXX A Declaration and Power of Attorney.
XXX A Verified Statement to establish Small Entity Status under 37 CFR 1.9 and 37 CFR 1.27.
XXX Return addressed stamped postcard.

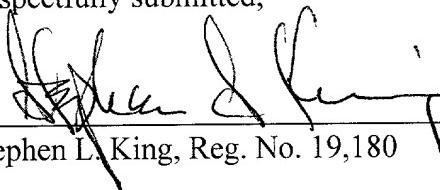
The Filing Fee has been calculated as shown below:

For:	(Col. 1) No. Filed	(Col.2) No. Extra	SMALL ENTITY		OTHER THAN A SMALL ENTITY	
			RATE	FEE	RATE	FEE
Basic Fee:	-	-	-	\$380.00	-	\$760.00
Total Claims:	-13	-0-	x \$9.00		x \$18.00	-0-
Indep. Claims:	-4	-1-	x \$39.00	39	x \$78.00	-0-
<input type="checkbox"/> Multiple Dep. Claim(s) Presented			+ \$130.00		+ \$260.00	-0-
* If the difference in (Col. 1) is less than zero, enter "0" in (Col. 2)			Total:	\$419.00	Total:	\$0.00

- XXX A check in the amount of \$459.00 is enclosed to cover the filing fee and recording the assignment..

Respectfully submitted,

Date: Oct 13, 1999


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Attorney's
Docket No. TRANS09

Applicant or Patentee: TRANSMETA CORPORATION
Serial or Patent No.: _____
Filed or Issued: _____

For: METHOD FOR INTEGRATION OF INTERPRETATION AND TRANSLATION IN A MICROPROCESSOR

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
37 CFR 1.9 (f) and 1.27(c) - - SMALL BUSINESS CONCERN

I hereby declare that I am an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN: TRANSMETA CORPORATION

ADDRESS OF CONCERN: 3940 FREEDOM CIRCLE, SANTA CLARA, CALIFORNIA 95054

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby certify that to the best of my knowledge and belief rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention entitled, METHOD FOR INTEGRATION OF INTERPRETATION AND TRANSLATION IN A MICROPROCESSOR,

by inventor(s) Robert Bedichek, Linus Torvalds, and David Keppel,
described in

[] the specification being filed herewith,

and I have reviewed the document that evidences the conveyance of those rights. That document

[] is being filed herewith.

If the rights held by the above-identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below and no rights to the invention are held by any person, other than the inventor, who could not qualify as a small business concern under 37 CFR 1.9(d) or by any concern which would not qualify as a small business concern under 347 CFR 1.9(d) or a non-profit organization under 37 CFR 1.9(e). NOTE:

Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

NAME: _____

ADDRESS: _____

[] Individual [] Small Business Concern [] Non-Profit Organization

NAME: _____

ADDRESS: _____

[] Individual [] Small Business Concern [] Non-Profit Organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING: DAVID DITZEL

TITLE OF PERSON OTHER THAN OWNER: PRESIDENT & CHIEF EXECUTIVE OFFICER

ADDRESS OF PERSON SIGNING: 3940 FREEDOM WAY, SANTA CLARA, CALIFORNIA 95054

SIGNATURE:  DATE: 29 Sept 29

APPLICATION FOR UNITED STATES LETTERS PATENT

FOR

**METHOD FOR INTEGRATION OF INTERPRETATION AND
TRANSLATION IN A MICROPROCESSOR**

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METHOD FOR INTEGRATION OF INTERPRETATION AND TRANSLATION
IN A MICROPROCESSOR

BACKGROUND OF THE INVENTION

5 Field Of The Invention

This invention relates to computer systems and, more particularly, to methods and apparatus for improving the operation of a new microprocessor adapted to execute programs designed for a processor having an instruction set different than the instruction set of the new microprocessor.

10 History Of The Prior Art

Recently, a new microprocessor was developed which combines a simple but fast host processor (called "morph host") and software (called "code morphing software") to execute application programs designed for a processor (the target processor) different than the morph host processor. The morph host processor executes the code morphing software to translate the application programs into morph host processor instructions which accomplish the purpose of the original target software. As the target instructions are translated, the new host instructions are both executed and stored in a translation buffer where they may be accessed without further translation. Although the initial translation and execution of a program is slow, once translated, many of the steps normally required to execute a program in hardware are eliminated. The new microprocessor has demonstrated that a simple fast processor designed to expend little power is able to execute translated

“target” instructions at a rate equivalent to that of the “target” processor for which the programs were designed.

In order to be able to execute programs designed for other processors at a rapid rate, the morph host processor includes a number of hardware 5 enhancements. One of these enhancements is a gated store buffer which resides between the host processor and the translation buffer. A second enhancement is a set of host registers which store state of the target machine at the beginning of any sequence of target instructions being translated. Generated as sequences of morph host instructions are executed and memory stores are placed in the gated store buffer. If the morph host instructions execute without raising an exception, the target state at the beginning of the sequence of instructions is updated to the target state at the point at which the sequence completed and the memory stores are committed to memory.

10
15 If an exception occurs during the execution of the sequence of host instructions which have been translated, processing stops; and the entire operation may be returned or rolled back to the beginning of the sequence of target instructions at which known state of the target machine exists in the set of host registers. This allows rapid and accurate handling of exceptions.

20
25 The combination of the code morphing software and the enhanced host processing hardware dynamically translates sequences of target instructions into sequences of instructions of a host instruction set which may be reused without being translated again. Moreover, the new processor also optimizes the translated instructions during and after the

initial translation. For example, sequences of host instructions translated from the target program may be reordered, rescheduled, and optimized in other manners to provide code which executes rapidly.

5 Optimized sequences of translated instructions may often be linked with other translated and optimized sequences of instructions so that the process may further optimized as the instructions continue to be executed. The new processor is described in detail in U. S. patent

10 5,832,205, Improved Memory Control System For Microprocessor, issued November 3, 1998, to E. Kelly et al., and assigned to the assignee of the present invention.

One difficulty which has limited the speed of operation of the improved microprocessor has been that many instructions being translated and stored for reuse are reused only infrequently if at all. Because the translation process is time consuming, the average time for execution of all translated instructions is lowered by translating these little used instructions. This is especially a problem where the translated sequences have been linked to other translated sequences and significantly optimized.

20 In addition to the time taken to translate and optimize sequences of instructions, each translation requires storage. If each translated sequence continues to be stored in the translation buffer, an inordinate amount of storage is ultimately required.

25 It is desirable to increase the speed of execution of instructions by the new microprocessor while reducing the storage required for translated instructions.

Summary Of The Invention

It is, therefore, an object of the present invention to increase the speed of execution of instructions by the new microprocessor while reducing the storage required for translated instructions.

5 This and other objects of the present invention are realized by a method for executing a target application on a host processor including the steps of translating each target instruction being to be executed into host instructions, storing the translated host instructions, executing the translated host instructions, responding to an exception during execution of a translated instruction by rolling back to a point in execution at which correct state of a target processor is known, and interpreting each target instruction in order from the point in execution at which correct state of a target processor is known.

10
15 These and other objects and features of the invention will be better understood by reference to the detailed description which follows taken together with the drawings in which like elements are referred to by like designations throughout the several views.

Brief Description Of The Drawings

Figure 1 is a logical diagram of a microprocessor designed in accordance with the present invention running an application designed for a different microprocessor.

20 Figure 2 is a block diagram illustrating the microprocessor shown in Figure 1.

Figure 3 illustrates the operation of a main translation loop of the microprocessor of Figure 1.

Figure 4 is a flow chart illustrating a method practiced by a microprocessor designed in accordance with the present invention.

5 Detailed Description

The new microprocessor 10 (shown in Figure 1) combines an enhanced hardware processing portion 11 (sometimes referred to as a "morph host" in this specification) which is much simpler than typical state of the art microprocessors and an emulating software portion 13 (referred to as "code morphing software" in this specification). The two portions function together as a microprocessor with advanced capabilities. The morph host 11 includes hardware enhancements to assist in providing state of a target computer immediately when an exception or error occurs, while the code morphing software 13 includes software which translates the instructions of a target program into morph host instructions, optimizes the translated instructions, and responds to exceptions and errors by providing correct target state at a point at which the translation is known to be correct so that correct retranslations can occur from that point.

20 Figure 1 shows morph host hardware designed in accordance with the present invention executing a target application program 14 which is designed to run on a CISC processor such as a X86 processor. The target application and the target operating are executed on the host hardware with the assistance of the code morphing software 13.

The code morphing software 13 of the microprocessor 10 includes a
translator portion 17 which decodes the instructions of the target
application, converts those target instructions on the fly (dynamically) to
host instructions capable of execution by the morph host, optimizes the
operations required by the target instructions for execution by the morph
host, reorders and schedules the primitive instructions into host
instructions (a translation) for the morph host, and executes the host
instructions.

In order to accelerate the operation of the new microprocessor, the code
morphing software includes a translation buffer 18 as is illustrated in
Figure 1. The translation buffer 18 is used to store the host instructions
which embody each completed translation of the target instructions once
the individual target instructions have been translated by the morph
host 11. The translated host instructions may thereafter be recalled for
execution whenever the operations required by the target instruction or
instructions are required.

Figure 3 illustrates the operation of a main (translation) loop of the code
morphing software. In a typical operation, the code morphing software of
the microprocessor, when furnished the address of a target instruction,
first determines whether the target instruction at the target address has
been translated. If the target instruction has not been translated, it and
subsequent target instructions are fetched, decoded, translated, and
then (possibly) optimized, reordered, and rescheduled into a new host
translation, and stored in the translation buffer by the translator.

Control is then transferred to cause execution of the translation by the
enhanced morph host hardware to resume.

When the particular target instruction sequence is next encountered in running the application, the host translation will be found in the translation buffer and immediately executed without the necessity of translating, optimizing, reordering, or rescheduling. Since the
5 translation for a target instruction will be found by the morph host in the translation buffer, the myriad of steps required by the typical target processor each time it executes any instruction are eliminated. This drastically reduces the work required for executing the instructions and increases the speed of the new microprocessor.

10 The morph host includes hardware enhancements especially adapted to allow the acceleration techniques provided by the code morphing software to be utilized efficiently over a much broader range of instructions. Many of these hardware enhancements are used to overcome the inability of prior art techniques to handle with decent performance exceptions generated during the execution of a target
15 program. Exceptions require that the correct target state be available at the time the exception occurs for proper execution of the exception and the instructions which follow.

In order to overcome these limitations, the enhanced morph host 11 of
20 the new processor (shown in block form in Figure 2) incorporates a gated store buffer 50 and a large plurality of additional processor registers 40. The gated store buffer 50 stores working memory state changes on an “uncommitted” side of a hardware “gate” and official memory state changes on a “committed” side of the hardware gate where these
25 committed stores are able to “drain” to main memory. An operation called “commit” transfers stores from the uncommitted side of the gate to

the committed side of the gate once execution of the translated code occurs without an exception. Some of the additional registers (called target registers) are used to hold the official state of the target processor at a last known correct condition; others are used as working registers.

5 The target registers are connected to their working register equivalents through a dedicated interface that allows a commit operation to quickly transfer the content of all working registers to official target registers and allows an operation called “rollback” to quickly transfer the content of all official target registers back to their working register equivalents. The
10 additional official registers and the gated store buffer allow the state of memory and the state of the target registers to be updated together once one or a group of target instructions have been translated and run without error.

15 If the primitive host instructions making up a translation of a series of target instructions are run by the host processor without generating exceptions, then the working memory stores and working register state generated by those instructions are transferred to official memory and to the official target registers. However, if an exception occurs when processing the translated host instructions at a point which is not on the
20 boundary of a sequence of target instructions being translated, the original state in the target registers at the last update (or commit) may be recalled to the working registers and uncommitted memory stores in the gated store buffer may be discarded. Then, the target instructions causing the target exception may be retranslated one at a time as they would be executed by a target microprocessor and the translated code
25 executed in serial sequence. As each target instruction is correctly

executed without error, the state of the target registers may be updated; and the data in the store buffer gated to memory. Then, when the target exception occurs again in running the host instructions, the correct state of the target computer is held by the target registers of the morph host and memory; and the exception may be correctly handled without delay.

In addition to simply translating the instructions, optimizing, reordering, rescheduling, storing, and executing each translation so that it may be rerun whenever that set of instructions needs to be executed, the translator also links the different translations to eliminate in almost all cases a return to the main loop of the translation process. Eventually, the main loop references in the branch instructions of host instructions are almost completely eliminated. When this condition is reached, the time required to fetch target instructions, decode target instructions, fetch the primitive instructions which make up the target instructions, optimize those primitive operations, reorder the primitive operations, and reschedule those primitive operations before running any host instruction is eliminated. Moreover, in contrast to all prior art microprocessors, long sequences of translated instructions exist which may be further optimized to increase the speed of execution.

A problem which has occurred with the new processor relates to those instructions of the target application which are seldom executed. For example, instructions required to initiate operation of a particular application are often executed only when the application is first called; and instructions required to terminate operation of an application are often executed only when the program is actually terminated. However, the new processor typically treats all instructions in the same manner. It

decodes a target instruction, fetches the primitive host instructions which carry out the function for which the target instruction is designed, proceeds through an extensive process of optimizing, and then stores the translated and optimized instruction in the translation cache. As the
5 operation of the new processor proceeds, the translated instructions are linked to one another and further optimized; and the translation of the linked instructions is stored in the translation buffer. Ultimately, large blocks of translated instructions are stored as super-blocks of host instructions. When an exception occurs during execution of a particular
10 translated instruction or linked set of instructions, the new processor goes through the process of rolling back to the last correct state of the target processor and then provides a single step translation of the target instructions from the point of the last correct state to the point at which the exception again occurs. In prior embodiments of the new processor,
15 this translation is also stored in the translation buffer.

Although this process creates code which allows rapid execution, the process has a number of effects which limit the overall speed attainable and may cause other undesirable effects. First, if a sequence of
20 instructions is to be run but once or a few times, the time required to accomplish optimizing may be significantly greater than the time needed to execute a step-by-step translation of the initial target instructions. This is especially true where the optimization accomplished includes linking translated sequences to one another. This overhead of the optimization tends to lower the average speed of the new processor.
25 Second, the process requires a substantial amount of storage capacity for translated instructions. Many times a number of different translations

exist for the same set of target instructions because the sequences were entered from different branches. Once stored, the translated instructions occupy this storage until removed for some affirmative reason.

- 5 To overcome these problems, the new processor utilizes as a part of the code morphing software, an interpreter which accomplishes step-by-step execution of target instructions. Such an interpreter could be stored as a part of host memory illustrated in Figure 2. Although there are many possible embodiments, an interpreter is essentially a program that
- 10 fetches a target instruction, decodes the instruction, provides a host process to accomplish the purpose of the target instruction, and executes the host process. When it finishes interpreting one target instruction and executing the host process to carry out the result commanded by the target instruction, the interpreter proceeds to the next target instruction.
- 15 This process essentially single steps through the target instructions. As each target instruction is interpreted, the state of the target processor is brought up to date. The interpretation process, in contrast to the translation process, does not store host instructions in the translation buffer for future execution. The interpreter continues the process for the
- 20 remainder of the sequence of target instructions.

An interpreter offers a number of advantages that are useful in certain situations. Because an interpreter causes the execution of host processes intended to carry out the purpose of each target instruction, it does not involve the complicated steps necessary to translate a sequence of target instructions. Since interpreted host processes typically are not

stored in the translation cache, linking and the further optimizations available after linking need not be carried out.

Not only does the use of an interpreter eliminate the need to optimize instructions which are not used during execution of the application and thereby increase the speed of operation, it also reduces the need for storage in the translation buffer and eliminates the need to discard many translated instructions. Interpretation may in fact be quite rapid as contrasted to translation and optimization for instructions which are little used during the execution of an application. Thus, a sequence of instructions which runs only once might be better and more rapidly handled by simply interpreting and never translating the sequence. Thus, for such instructions it may be desirable to utilize the interpreter instead of the translator software.

In order to make use of these advantages, the new processor includes apparatus and a method illustrated in Figure 4 for running the interpreter whenever a sequence of target instructions is first encountered. The interpreter software may be associated with a counter which keeps track of the number of times sequences of instructions are executed. The interpreter may be run each time the sequence is encountered until it has been executed some number of times without generating an exception. When the particular sequence of target instructions has been interpreted some selected number of times, the code morphing software switches the process from the interpreter to the translation, optimization, and storage process. When this occurs, the sequence will have been executed a sufficient number of times that it is probable that execution of the sequence will reoccur; and a stored

optimized translation will provide significantly faster execution of the application as a whole from that point on.

When the code morphing software switches to the translation process, the translation is optimized and stored in the translation cache.

5 Thereafter, that translation may be further optimized and linked to other translations so that the very high speeds of execution realized from such processes may be obtained.

An especially useful embodiment records data relating to the number of times a target instruction is executed by the interpreter only at points at which branches occur in the instructions. The interpreter single steps through the various target instructions until a branch occurs. When a branch instruction occurs, statistics regarding that particular branch instruction (the instruction with the particular memory address) are recorded. Since all of the target instructions from the beginning of a sequence until the branch will simply be executed in sequential order, no record need be kept until the point of the branch.

Moreover, if the interpreter is utilized to collect statistics in addition to the number of times a particular target instruction has been executed, additional significant advantages may be obtained. For example, if a target instruction includes a branch, the address of the instruction to which it branches may be recorded along with the number of times the branch has been executed. Then, when a number of sequential target instructions are executed by the interpreter, a history of branching and branch addresses will have been established. From this, the likelihood of a particular branch operation taking place may be determined. These

statistics may be utilized to guide super-block formation. By utilizing
these statistics, a particular sequence of instructions may be
speculatively considered to be a super-block after being executed a
significant number of times. After being interpreted for the selected
5 number of times, the sequence may be translated, optimized, linked
through the various branches without the necessity to go through a
separate linking operation, and stored as such in the translation cache.
If the speculation turns out to be true, then significant time is saved in
processing the instructions. If not, the operation causes an exception
10 which returns the code morphing software to the interpreter.

It has been discovered that, in addition to handling the generation of
host instructions some initial number of times when a sequence of target
instructions is first encountered, the interpreter may also be used
advantageously when a translated sequence of instructions encounters
an exception. In accordance with the present invention, whenever the
15 new processor encounters a target exception while executing any
sequence of host instructions translated from a sequence of target
instructions, the code morphing software causes a rollback to occur to
the last known correct state of the target processor. Then, the
20 interpreter portion of the code morphing software is utilized rather than
the translator portion to execute the sequence of instructions. The
interpreter proceeds to interpret the target instructions to the point at
which the exception occurred.

The interpreter carries out each individual one of the target instructions
25 in the sequence on a step by step basis. The interpreter fetches a target
instruction, decodes the instruction, provides a host process to

accomplish the purpose of the target instruction, and executes the host process. When it finishes interpreting one target instruction and executing the host process to carry out the result commanded by the target instruction, the interpreter proceeds to the next target instruction.

- 5 As each target instruction is interpreted and executed, the state of the target processor is brought up to date. The interpreter continues this process for the remainder of the sequence of target instructions until the exception again occurs. Since target state is brought up to date as each target instruction is interpreted, the state is correct at that point to correctly handle the exception.

10 The interpreter handles exceptions as well as the translator but offers many additional benefits. Because the interpretation process is simple, the process of determining the point of occurrence of a target exception is significantly faster than the determination of such a point when carried out by the translation process which goes through the above-described 15 translation and optimization process and then stores host instructions in the translation buffer.

- 20 The use of the interpreter to handle the process of determining the state of the target processor at the point of a target exception eliminates the need to translate and store the host instructions used to determine that state.

25 By utilizing the combination of the interpreter and the optimizing translator which functions as a dynamic compiler of sequences of translated instructions to handle exceptions generated during execution of translated sequences of instructions, the code morphing software

significantly enhances the operations of the new processor. The use of the interpreter to handle exceptions has the same useful effects as using a translator for this purpose while speeding operations and reducing storage requirements.

- 5 Although the present invention has been described in terms of a preferred embodiment, it will be appreciated that various modifications and alterations might be made by those skilled in the art without departing from the spirit and scope of the invention. The invention should therefore be measured in terms of the claims which follow.

10 What Is Claimed Is:

1 Claim 1. A method for executing a target application on a host
2 processor comprising the steps of:

3 translating into host instructions each of a sequence of target
4 instructions,

5 storing the translated host instructions,

6 executing the stored host instructions, and

7 responding to an exception during execution of a stored translated
8 instruction by rolling back to a point in execution at which correct state
9 of a target processor is known, and

10 interpreting each target instruction in order from the point in execution
11 at which correct state of a target processor is known.

1 Claim 2. A method as claimed in Claim 1 which further comprises:

1 collecting statistics regarding the execution of sequences of instructions
2 which are interpreted.

1 Claim 3 . A method for executing a target application on a host
2 processor comprising the steps of:

3 executing host instructions representing each target instruction of the
4 target application;

5 responding to an exception during execution of host instructions
6 representing a target instruction by returning to a point in execution of
7 the target application at which correct state of a target processor is
8 known; and

9 thereafter executing host instructions by interpretation of the target
10 instruction until the point of the exception.

1 Claim 4. A method as claimed in Claim 3 which further comprises
2 collecting statistics regarding the execution of sequences of target
3 instructions which are executed.

1 Claim 5. A method as claimed in Claim 4 in which the statistics
2 include the number of times the sequence of target instructions have
3 executed.

1 Claim 6. A method as claimed in Claim 4 in which the statistics
2 include address of an instruction to which a target instruction including
3 a branch operation branches.

1 Claim 7. A method as claimed in Claim 4 in which the statistics
2 include a likelihood of a branch being taken.

1 Claim 8. A system for executing a target application designed for
2 execution on a target processor on a host processor having an
3 instruction set different than that of the target processor comprising:

4 means for translating sequences of target instructions and storing each
5 translated sequence of instructions,

6 means for selecting a stored translated sequence of instructions for
7 execution,

8 means for responding to an exception during execution of a stored
9 translated instruction by rolling back to a point in execution at which
10 correct state of a target processor is known, and

11 means for interpreting each target instruction in order from a point in
12 execution at which correct state of a target processor is known through
13 the target instruction causing the exception.

1 Claim 9. A system as claimed in Claim 8 in which the means for
2 interpreting is an interpreter software executing on the host processor,
3 and

4 the means for translating is dynamic translation software executing on
5 the host processor.

1 Claim 10. A method for executing a target application on a host
2 processor comprising the steps of:

3 interpreting each of a sequence of target instructions a plurality of times,
4 collecting statistics regarding the execution of the instructions in the
5 sequence of instructions as the sequence is interpreted,
6 using the statistics to determine when to cease interpreting target
7 instructions,

8 translating into host instructions each of the sequence of target
9 instructions after stopping interpreting the sequence,

10 storing the translated host instructions, and

11 executing the stored host instructions when the sequence of target
12 instructions is to be executed.

1 Claim 11. A method as claimed in Claim 10 in which the statistics
2 include the number of times the sequence of target instructions have
3 executed.

1 Claim 12. A method as claimed in Claim 10 in which the statistics
2 include an address of an instruction to which a target instruction
3 including a branch operation branches.

1 Claim 13. A method as claimed in Claim 10 in which the statistics
2 include a likelihood of a branch being taken.

Abstract of the Disclosure

A method for executing a target application on a host processor including the steps of translating each target instruction being to be executed into host instructions, storing the translated host instructions, executing the
5 translated host instructions, responding to an exception during execution of a translated instruction by rolling back to a point in execution at which correct state of a target processor is known, and interpreting each target instruction in order from the point in execution at which correct state of a target processor is known.

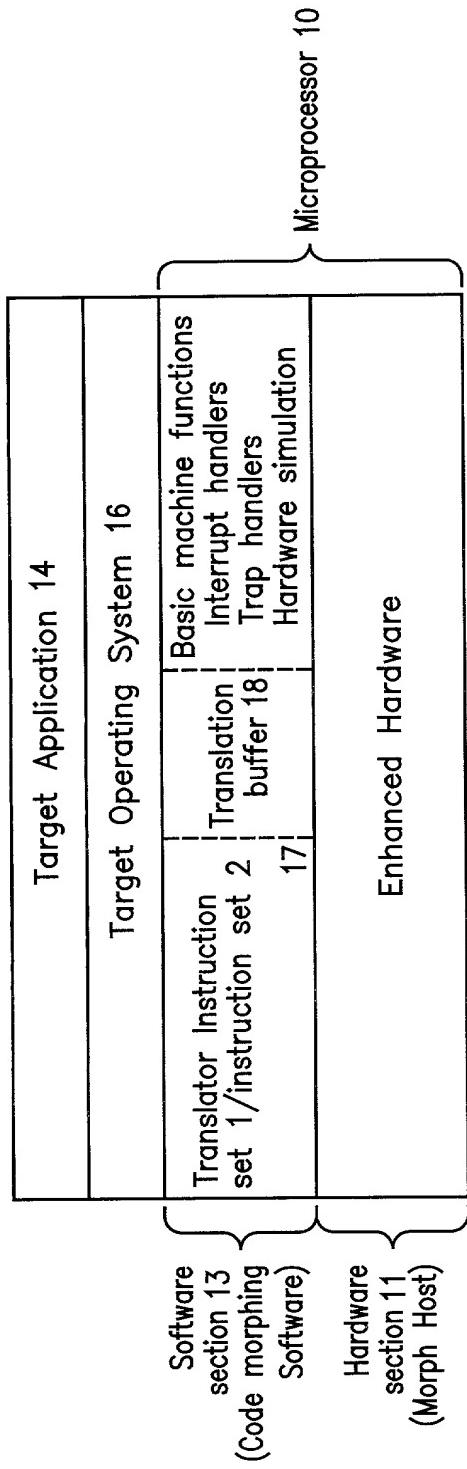


Fig. 1

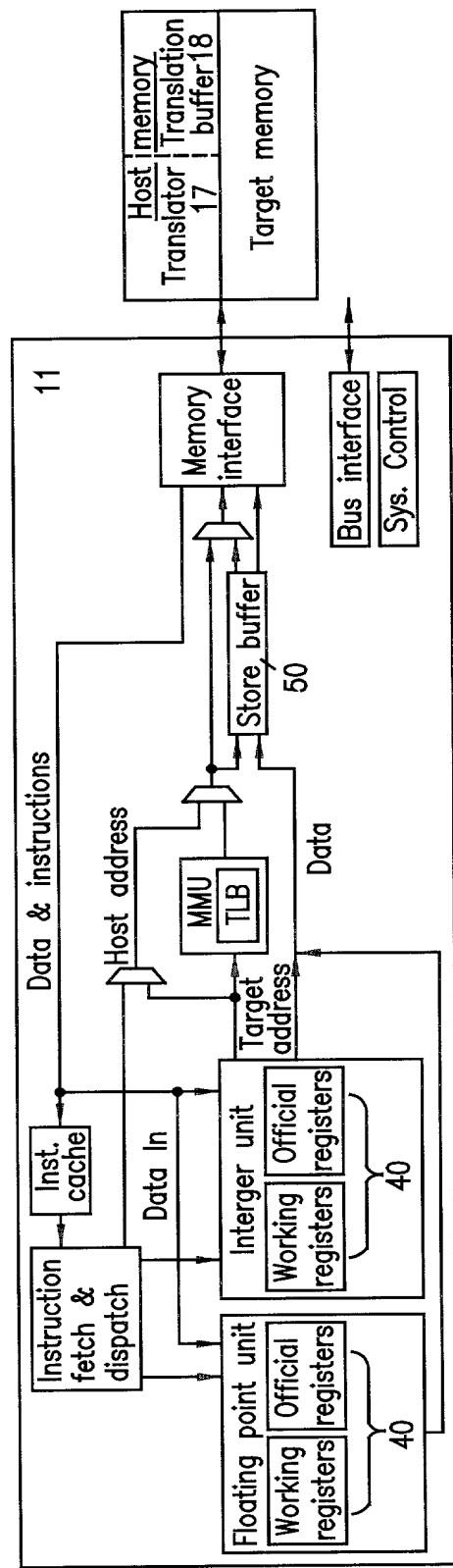


Fig. 2

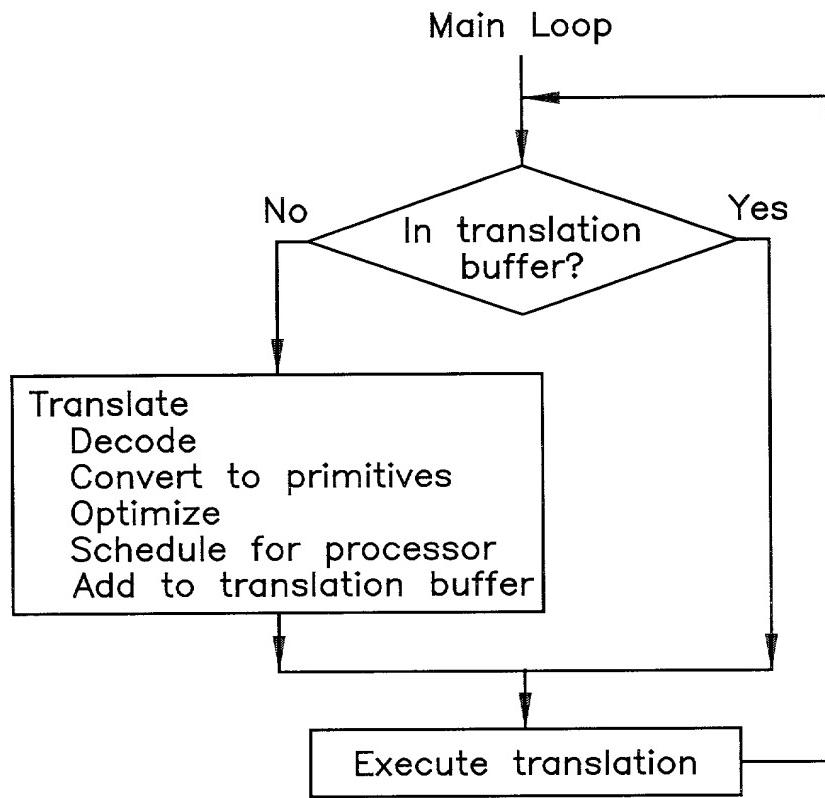


Fig. 3

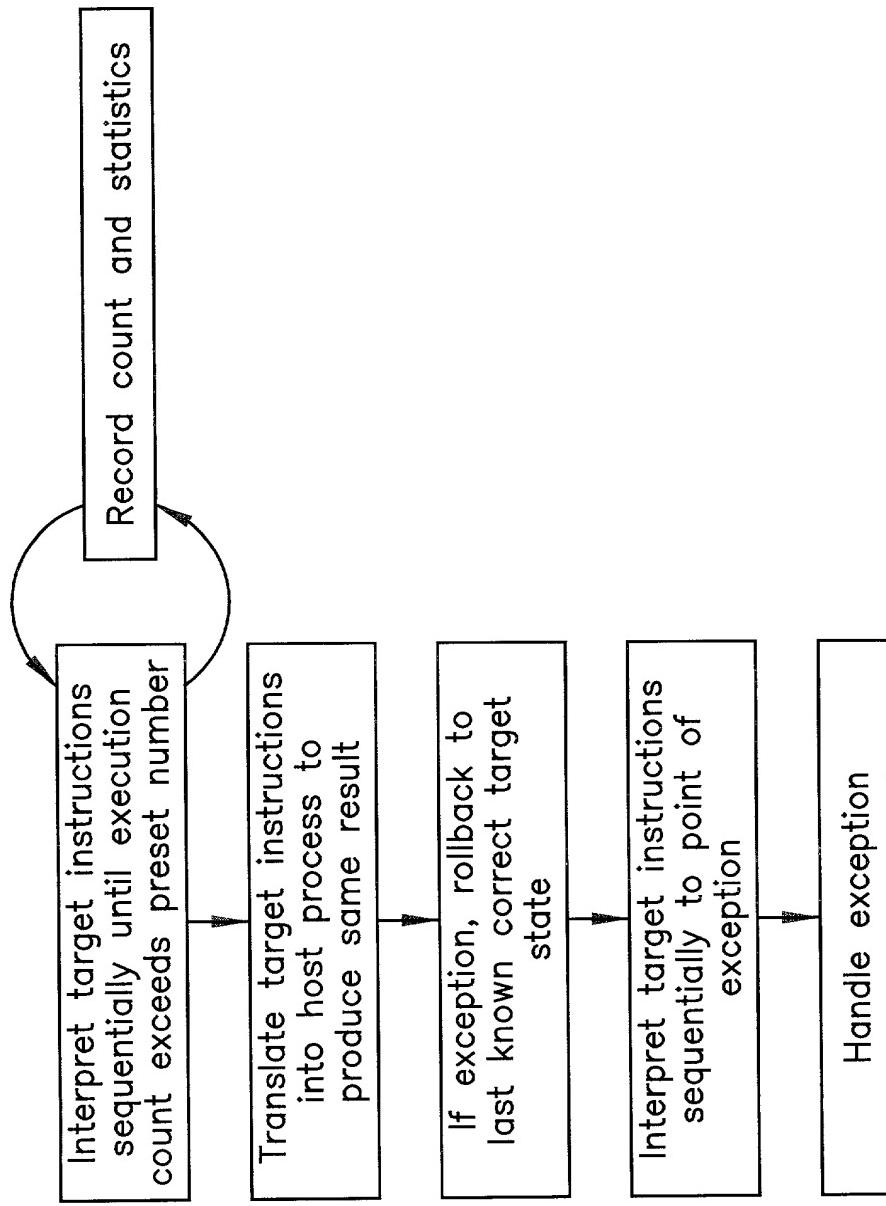


Fig. 4

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD FOR INTEGRATION OF INTERPRETATION AND TRANSLATION
IN A MICROPROCESSOR

the specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby appoint Stephen L. King, Reg. No. 19,180; with offices located at 30 Sweetbay Road, Rancho Palos Verdes, California 90275, telephone (310) 377-5073, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of

Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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